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Are self-adhesive resin cements a valid alternative to conventional resin cements? A laboratory study of the long-term bond strength

Thomas Hitz[a,*], *Bogna Stawarczyk*[a], *Jens Fischer*[b], *Christoph H.F. Hämmerle*[a], *Irena Sailer*[a]

[a] *Clinic of Fixed and Removable Prosthodontics and Dental Material Science, Center of Dental Medicine, University of Zurich, Zurich, Switzerland*
[b] *Institute of Dental Materials and Technology, School of Dental Medicine, University of Basel, Basel, Switzerland*

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ABSTRACT

Objectives. The aim of the study was to test whether or not the shear bond strengths of six self-adhesive resin cements to dentin and to glass-ceramic, 24 h and long-term-aged, are similar to the one of a conventional resin cement.

Methods. Human molars ($N = 168$, $n = 12$ per group) and silicabased glass-ceramic specimens ($N = 168$, $n = 12$ per group) were embedded in acrylic resin and randomly divided into 28 groups. The following resin cements were luted according to the manufacturers' instructions: Clearfil SA (CSA), G-Cem (GCM), SmartCem2 (SMC), SpeedCEM (SPC), RelyX Unicem (RXU), RelyX Unicem2 (RXU2) and Panavia21 (control group, PAN). Shear bond strength was measured initially (24 h of water storage 37 °C) and after aging (24,000 thermal cycles, 5/55 °C). The failure types (adhesive, and cohesive) were evaluated after debonding. The shear bond strength values were analyzed using three-way and one-way ANOVA, followed by a post hoc Scheffé and two-sample Student's *t*-tests.

Results. RXU, RXU2 and GCM showed similar after 24 h and aged shear bond strength to dentin as the control group. CSA, SMC and SPC exhibited significantly lower values. Before aging, none of the bond strength values to glass-ceramic differed significantly from the other. After thermocycling, GCM showed higher results to glass-ceramic than CSA, SMC, RXU2 and the control group. Analyzing failure types after spontaneous debonding and shear bond test at dentin, solely adhesive failures were found, while at glass-ceramic only cohesive failures occurred.

Conclusion. Not all self-adhesive resin cements can be a valid alternative to conventional resin cements in order to bond silica-based glass-ceramics to human dentin.

* *Corresponding author at*: Clinic of Fixed and Removable Prosthodontics and Dental Material Science, Center of Dental Medicine, University of Zurich, Plattenstrasse 11, 8032 Zurich, Switzerland. Tel.: +41 44 634 32 57; fax: +41 44 634 43 05.
E-mail address: thomashitz@yahoo.com (T. Hitz).

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1. Introduction

The available cements in dentistry can be classified into water-based and resin-based polymerizing cements [1]. Water-based cements include glass-ionomer and zinc phosphate cements, whereas polymerizing cements comprise resin composites, adhesive cements and resin-modified glass-ionomer cements. Chemical bonding of water-based cements to tooth tissues or restoration materials is only low (for glass-ionomer cements) or not existent (for zinc phosphate cement) [2]. In contrast, polymerizing cements constitute some chemical and mechanical connection to the tooth and to the restoration [3,4].

The type of cementation may influence the outcome of the reconstruction depending upon restorative material the reconstruction is made out of, i.e. glass-ceramic, oxide ceramics and composites [5,6]. Several studies showed that silica-based glass-ceramic restorations exhibit better clinical long-term stability when luted with polymerizing resin-based cements instead of water-based cements [5,6]. When polymerizing resin-based cements were applied, the fracture resistance of silica-based glass-ceramic crowns increased significantly [7]. Hence, this restorative materials require to be reinforced by adhesive cementation [7–9].

In order to achieve a good bonding between the polymerizing resin-based cement and the substrates, i.e. the restorative material and the tooth substance, several pre-treatment bonding steps are required. These pre-treatment steps are technique sensitive and, therefore, prone to handling errors. It has been shown that polymerizing cements are very technique sensitive. Handling problems like, e.g. contamination of the substrate with saliva or blood significantly reduce the bond strength of the respective polymerizing cement [10–12].

To facilitate the pretreatment procedures of the tooth tissue, self-adhesive resin cements were recently developed. Self-adhesive resin cements are polymerizing cements, which bond to the substrate, more specifically to dentin, without the pre-treatment with bonding solutions. The first introduced and well documented self-adhesive resin cement is RelyX Unicem (3M ESPE, Germany). In order to achieve a self-adhesive reaction of this cement to the tooth structure, new methacrylate monomers with phosphoric acid groups were implemented. This results in a low pH value and hydrophilic properties in the beginning of the setting. Subsequently, the negatively charged groups of the monomer bind to Ca^{2+} ions of the tooth and in combination with the alkaline part of the fillers a neutralization reaction follows [13]. Several in vitro and clinical studies showed promising results of RelyX Unicem with respect to bond strength [14–17]. The chemical reaction of most of the other self-adhesive cements have not been clearly announced yet by the manufacturers.

Within the last years, several new self-adhesive resin cements have been introduced [18]. At present, no scientific literature is available of the newly introduced self-adhesive resin cements and their bond strength after long-term aging. Whereas studies show that aging can have a negative impact on the shear bond strength of conventional resin cements [20], the bond strength of the newly introduced self-adhesive resin cements after long-term aging has not been investigated yet [21]. Good long-term bonding capacity, however, is desired for clinical long-term success. As mentioned before, reconstructions made out of weak silica-based ceramics need to be reinforced by the adhesive cementation. Consequently, the self-adhesive resin cements should be to establish good long-term bonding not only to the tooth substance, but also to the ceramic. Hence, laboratory studies of the new self-adhesive resin cements are needed, which simulate the oral conditions and age the adhesive interfaces to measure the long-term bonding capacity to tooth and to the reconstruction material [19].

Therefore, the aim of this study was to test whether or not various self-adhesive resin cements exhibit similar shear bond strength to the substrates dentin and glass-ceramic as a conventional resin cement.

The null-hypothesis was that the shear bond strength of self-adhesive resin cements to both substrates is similar to the conventional cement both initially, and after long-term aging.

2. Material and methods

Six self-adhesive resin test cements were included in the study. One conventional resin cement acted as control group. Table 1 gives detailed information of all tested cements. 168 teeth were divided into 14 groups of twelve each. Additionally 168 ceramic specimens were divided into 14 further experimental groups of twelve each (Fig. 1).

2.1. *Preparation of human dentin specimens*

For this study 168 caries-free human molars were used. The teeth were cleaned from remnant soft tissue and stored in 0.5% chloramine T at room temperature during the first 7 days after extraction and thereafter stored in distilled water at 5 °C for a maximum of 6 months. They were ground flat with silicon carbide polishing paper P80 (Labo-Pol-21; Struers, Ballerup, Denmark) under water-cooling and subsequently embedded in a cylindrical form by acrylic resin (ScandiQuick, ScanDia, Hagen, Germany). The teeth were ground with SiC P500 until a dentin surface area of at least 5 mm^2 was exposed. Immediately prior to the luting procedure, the dentin specimens of the control group were pretreated according to the respective manufacturer's recommendations (Table 2).

2.2. *Preparation of glass-ceramic specimens*

Glass-ceramic ingots (VITA Mark II, VITA Zahnfabrik, Bad Säckingen, Germany) were embedded in acrylic resin ScandiQuick (ScanDia, Hagen, Germany) and cut from cylindrical rods into slices of 5 mm thickness by a cutting machine (Accutom 50, Struers, Ballerup, Danemark). The specimens were flattened with a polishing machine with P2400 silicon carbide polishing paper (SCAN DIA, Hagen, Germany). The surfaces of the glass-ceramic specimens were etched with 5% hydrofluoric acid for 60 s (VITA Ceramics Etch; VITA Zahnfabrik, Bad Säckingen, Germany, LOT 12150), rinsed with water, cleaned with alcohol, dried with oil-free air, and silanized according to the respective manufacturer's recommendations (Table 2).